

INTERPLANETARY MEDIUM AND IONOSPHERIC INVESTIGATIONS WITH NEW WIDE-BAND ACTIVE ANTENNA ARRAY

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Abstract

The results of the development of prototype of a new generation low frequency telescope are discussed. The comparison of the efficiency of the new wide-band active antenna array and the part of the UTR-2 radio telescope is given. The radio astronomy observations carried out have shown high efficiency of the new active antenna array.

1 Introduction

It is known that wide-band observations of ionospheric and interplanetary scintillations are very important for the investigations of the near Earth space plasma turbulence. In particular, they allow to obtain a spectrum of plasma-density irregularities in the Solar wind and the ionosphere in a wide band of spatial frequencies. However, until the present time ionosphere and interplanetary scintillations spectra and the possibility of their reliable separation at long wavelengths have not been well studied. During recent years the interest in decameter wave radio astronomy has considerably increased, in particular, in connection with the plans of the construction of a huge low frequency radio telescope. Conceptions of creation of new generation low frequency instruments are actively discussed in many countries, including both space-borne and ground-based approaches. The last one implies building telescopes with a giant effective area of more than one million square meters.

2 Antenna development

To probe possible ways of such a ground-based telescope development a prototype of a new generation low frequency telescope, consisting of active wide-band dipoles, was built

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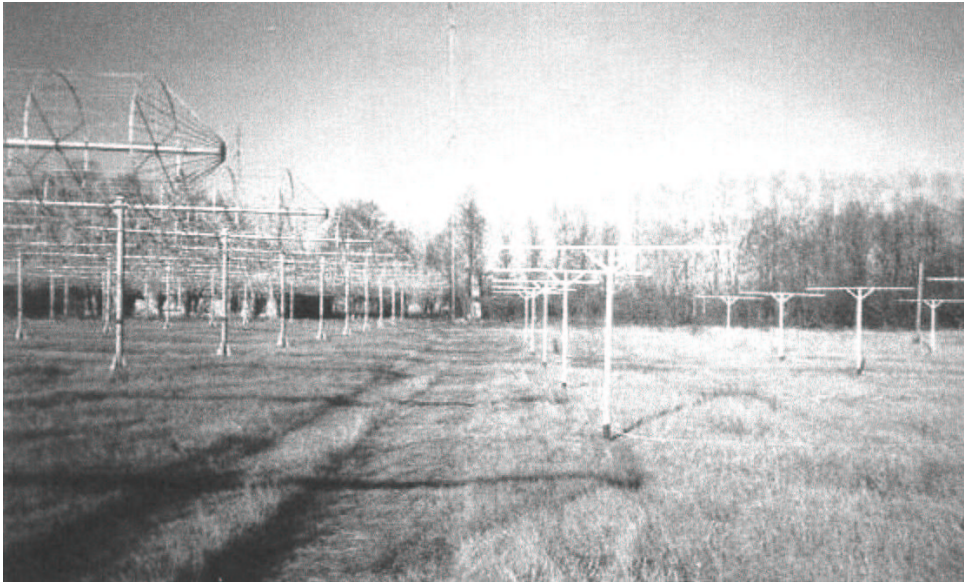


Figure 1: The new active antenna array.

in 2000 by the Radio Astronomy Institute's team. An active element was made as a thin, 3 meters long dipole with a built-in amplifier.

Outward appearance of the antenna is shown in Figure 1, and its functional scheme - in Figure 2. The array contains 30 elements: 5 rows with 6 dipoles. Each row is phased by the phase-shifter, which provides 4 beam positions. Rows are united by phase-shifter (5 beam positions). Each dipole is equipped with a specially designed high-linear low-noise amplifier (Figure 3). The same amplifiers are used to compensate losses in phase-shifters and in trunk cables.

The principal array parameters are the following:

- frequency range - 10 .. 70 MHz;
- the number of elements - 30;
- sector of electronic tracking - 70 degree from zenith for both coordinates;
- total antenna's size - 45 m x 30 m;
- effective area at 20 MHz - 1500 m²;
- antenna pattern's width at the frequency 60 MHz - 6 degree x 10 degree;
- excess of antenna temperature under noise preamplifier temperature > 8 ;
- dynamic range of antenna amplifier ~ 90 dB.

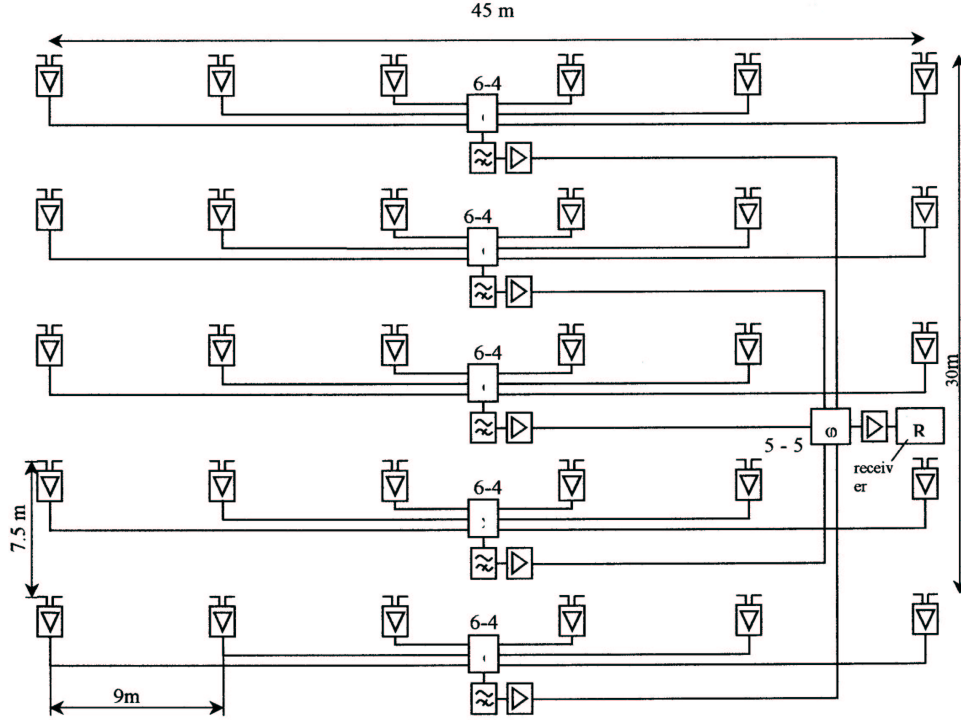


Figure 2: Functional scheme.

3 Approbation

The results of comparison between sensitivity of the new array and sensitivity of UTR-2 part having analogous area and configuration are shown in Figure 4 and Figure 5 (one element of UTR-2 is a thick, 8 meters long wide-band dipole with frequency range 10–30 MHz). Radio source Cassiopeia A was observed near 20 MHz. Figure 4 and Figure 5 practically coincide, that indicates equal sensitivities of both antennas, first of which contains significantly shorter and easier to construct elements.

Dynamic spectra of Cassiopeia A ionospheric scintillations in the frequency range 10–70 MHz are shown in Figure 6 and Figure 7. Frequency and time resolutions are 30 kHz and 350 msec., correspondingly. In order to obtain these results the Hewlett-Packard wide-band spectrum analyzer was used with the active antenna. The frequency drift of scintillations is well noticeable in this frequency range in Figure 6. The scintillations, caused by focusing ionospheric irregularities are localized in time at low frequencies. With the frequency increasing the more fine structure of focusing irregularities is shown by the spectra. The fine structure is demonstrated by splitting the dynamic spectrum into 3–4 separate features. In Figure 6 at 17:01 UT the antenna was declined by 3 min from the observed source. The strong darkening in the figure at this time characterizes high sensitivity of the active antenna in a wide frequency range up to 70 MHz. It is obvious, that such wide-band observations of ionospheric and interplanetary scintillations are very important for studying near Earth space plasma turbulence.

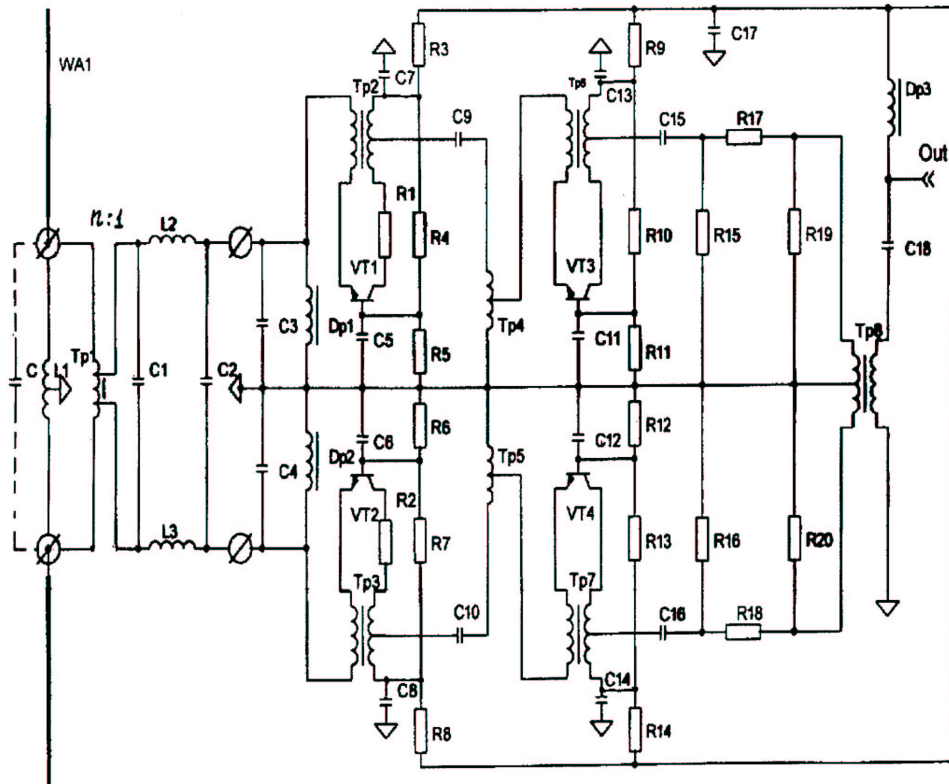


Figure 3: Schematic diagram of low-noise amplifier.

Observations of Cassiopea A scintillations. 03.11.2000 by New Radio Astronomy Active array

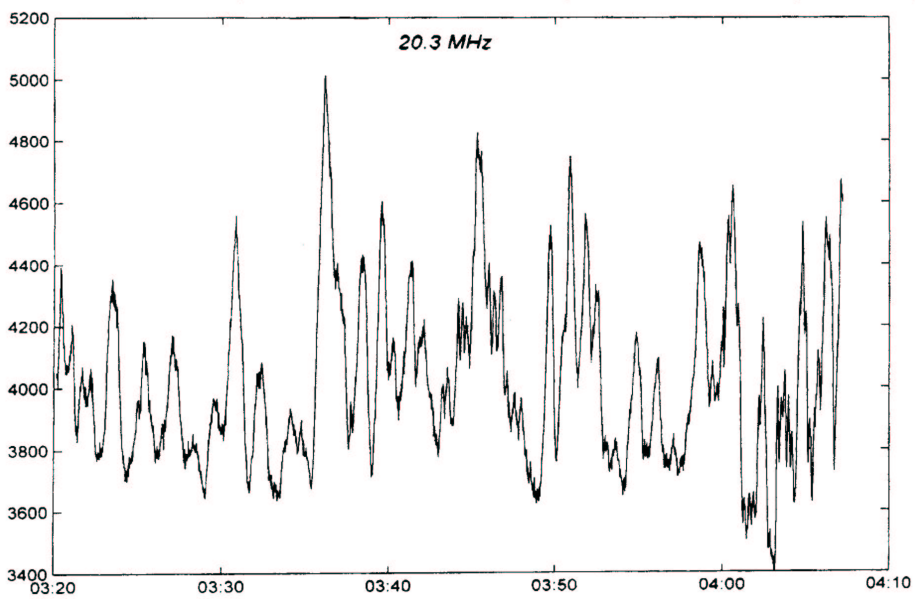


Figure 4: Cassiopeia A scintillations obtained by the new active antenna array.

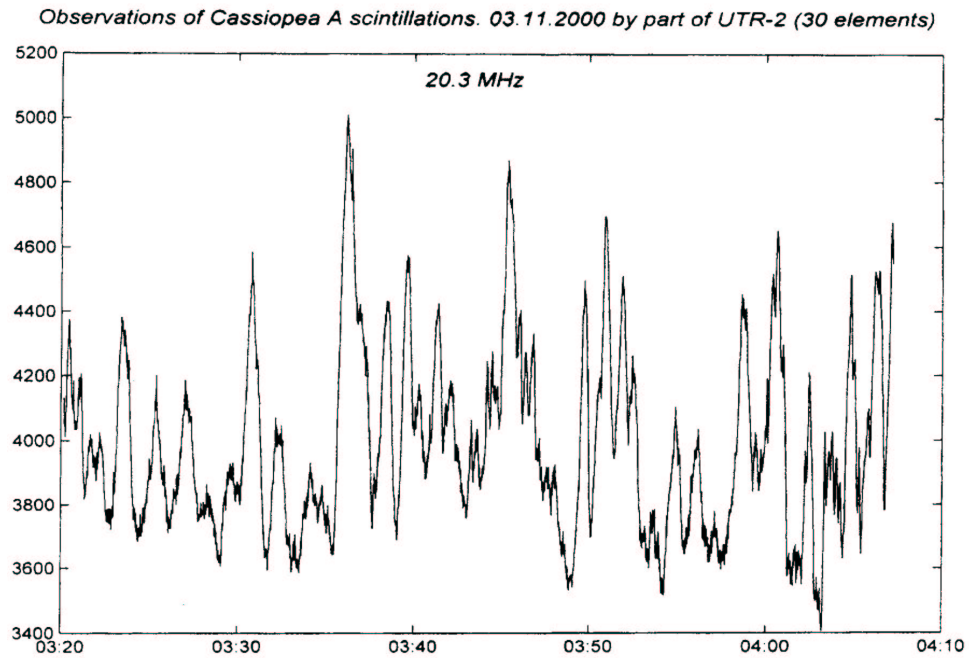


Figure 5: Cassiopeia A scintillations obtained by the part of UTR-2 radiotelescope (30 elements).

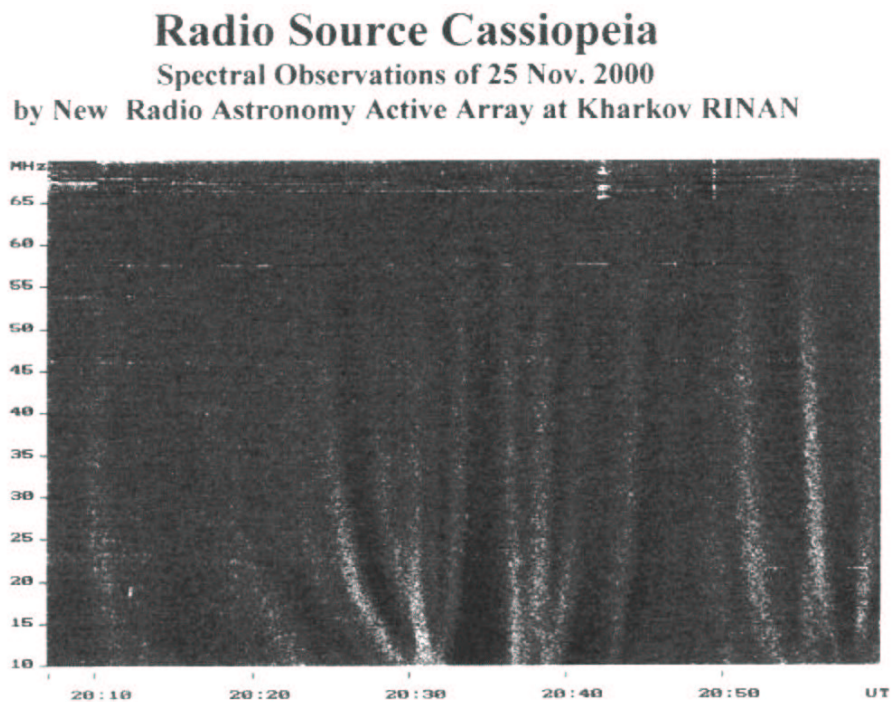


Figure 6: Dynamic spectra of Cassiopeia A scintillations.

Radio Source Cassiopeia ON-OFF
Spectral Observations of 25 Nov. 2000
by New Radio Astronomy Active Array at Kharkov RINAN

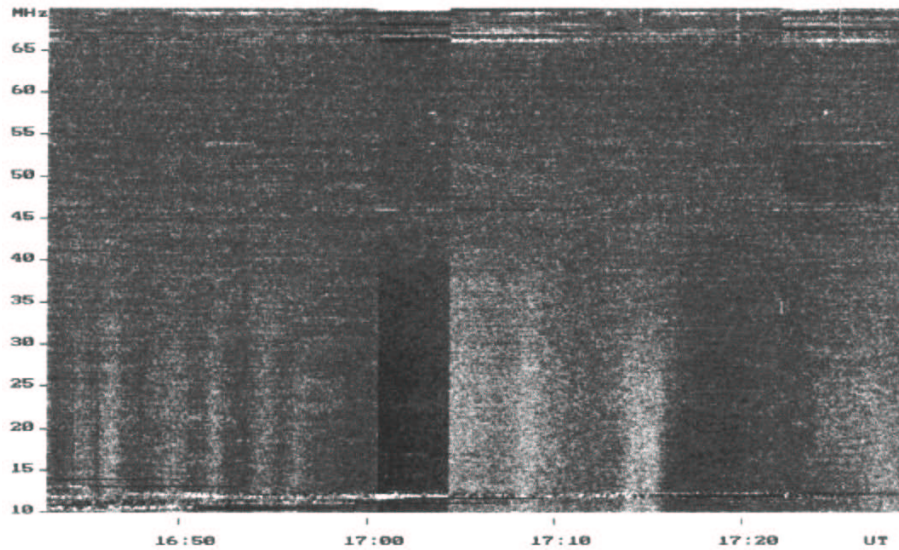


Figure 7: Radio source Cassiopeia A on-off.

Radio Bursts from SUN
Spectral Observations of 25 Nov. 2000
by New Radio Astronomy Active Array at Kharkov RINAN

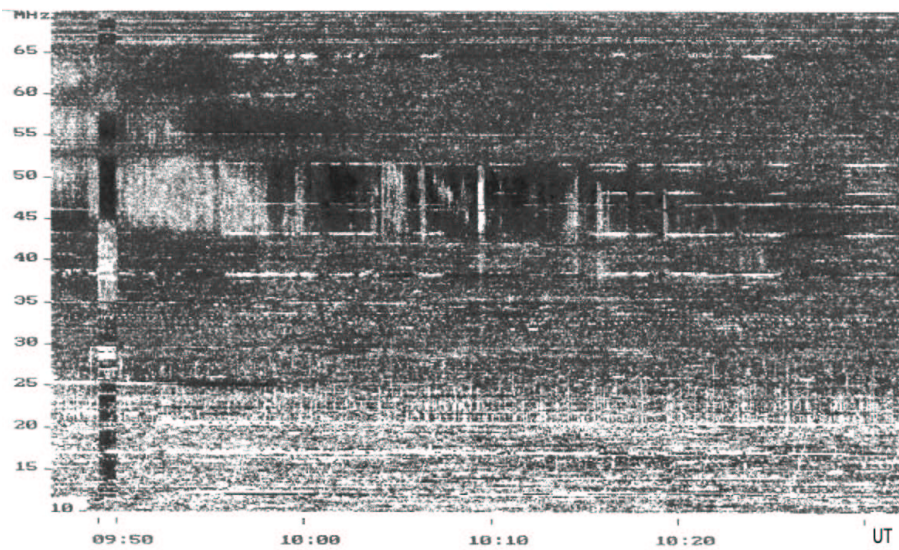


Figure 8: Solar radio burst.

Radio Bursts from Planet JUPITER
Spectral Observations of 25 Nov. 2000
by New Radio Astronomy Active Array at Kharkov RINAN

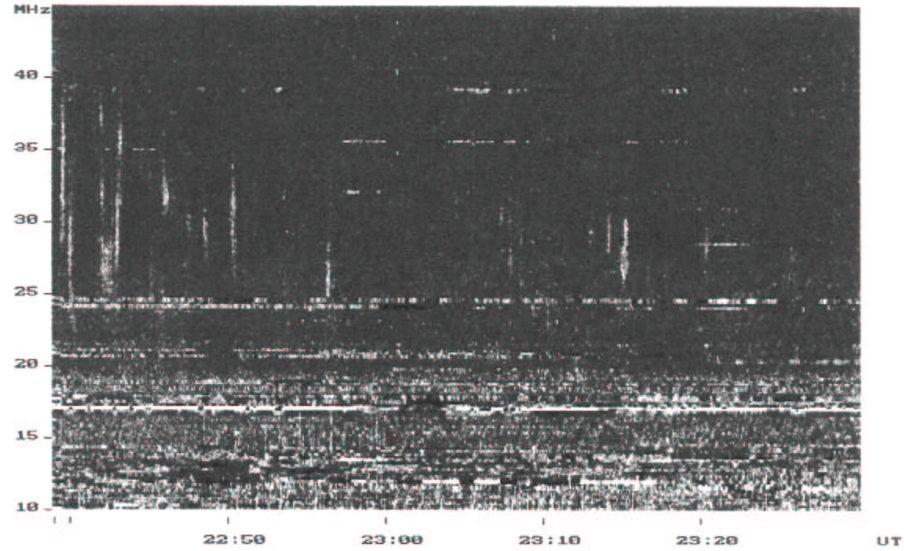


Figure 9: Jupiter's radio bursts.

4 Conclusion

The 30-elements active antenna array described above is a prototype of a huge radio telescope, and has a rather small effective area and angle resolution. Nevertheless, it allows to carry out wide-band radio astronomic observations of Solar system objects which do not require high sensitivity and angle resolution. As an example the dynamic spectra of the sporadic Solar and Jupiter radio emissions obtained by using the wide-band spectrum analyzer mentioned above are shown.